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ARCH TO MEET U.S. WORLD FOOD NEEDS

VOLUME II

OF A WORKING CONFERENCE



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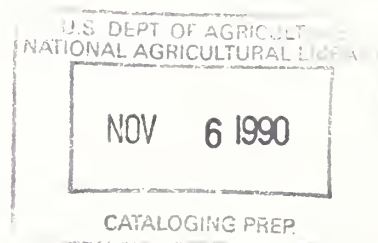
RESEARCH TO MEET U.S. AND WORLD FOOD NEEDS

Report of a Working Conference
sponsored by the
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Kansas City, Missouri

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VOLUME II

RESEARCH TO MEET U.S. AND WORLD FOOD NEEDS

This is the second volume of the report on the Working Conference on Research to Meet U.S. and World Food Needs, held in Kansas City, Missouri, July 9-11, 1975. This volume contains the background information on the world food situation, food policies, and agricultural research that was provided to the delegates and participants at the Conference. The material has been updated in accordance with data provided by Conference speakers.

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WORLD FOOD SITUATION

Emergence of a Crisis

The world suddenly became generally aware of a food crisis in 1972, when, after more than two decades of steady yearly increases, worldwide crop output dropped almost 2 percent. The immediate cause was bad weather in various parts of the globe. The crisis had its origins, however, in longer-term economic, political, and social trends. Two important developments leading to the food shortages of 1972 and afterward were (a) increased reliance on food imports by the developing nations, and (b) relatively low prices leading to less-than-maximum crop output in the developed nations.

The first of these factors--steadily increasing demand for food imports by many developing countries during the 1950's and 1960's--resulted from both rapid population growth and higher living standards. Food production failed to keep pace with population growth in several of the most densely populated countries. In even more parts of the world, food production fell behind total food demand. The developing nations, which had been net exporters of grain before World War II, became substantial net importers during the 1950's. By the late 1960's, despite some good harvest years, food imports were a substantial drain on their resources. Besides the economic stress involved, there were two other important effects: the developing nations grew increasingly dependent on food imports, and world food reserves came under increasing pressure (1).

Meanwhile, the relatively low level of food prices in the developed nations--especially from 1967 to 1971--eased the immediate food problems of the developing countries, but also encouraged their dependence on imports. In addition, low prices led to increased use of grain for livestock feed. Possibly most significant, they also brought about governmental programs to lower crop production in many developed countries, thus further reducing the world's food reserves (5).

By the early 1970's, increasing worldwide demand for food and shrinking food reserves were approaching the balance point. Only one poor crop season was needed to bring on worldwide food shortages; and that season came in 1972.

The crisis was vastly complicated. Economic boom and surging demand in the developed nations, devaluation of the dollar, and worldwide

monetary instability all made the situation worse. In response to large purchases by Russia and the People's Republic of China, grain prices rose especially sharply--a particular problem for those with low incomes in the developing countries. Simultaneously, food aid programs were drastically reduced, forcing developing nations to commit even more of their financial resources to pay for food imports. Besides these factors, the energy crisis put sudden and intense pressure on the world's food production systems, chiefly by boosting the cost of fertilizer and by adding to balance-of-payments problems.

Since 1972, these trends, plus the crucial short-term factor of weather, have combined to create a continuing worldwide food crisis. By the middle of 1973, wheat stocks held by the exporting nations were at the lowest level in 20 years. World prices for major agricultural commodities, after years of relative stability, doubled or tripled by 1974. Increases were greatest for wheat, corn, oilseed cake and meal, wool, cocoa, rubber, rice and sugar (5). In addition to their global economic impact, high food prices added to severe problems of human nutrition in various parts of the world. The UN Food and Agriculture Organization (FAO) estimated that 57 out of 97 developing countries had a deficit in food energy (calorie) supply in 1970. A conservative estimate, not including the more recent effects of worldwide food price rises, is that about 460 million people in the world are suffering from malnutrition or worse (3).

Widespread malnutrition and even famine are, of course, not new events in world history. But the food crisis of the 1970's has demonstrated at least one important difference--that worldwide economic interdependencies are involved. Poor 1972 harvests in such diverse areas as India, Australia, Africa and the USSR were reflected immediately in food price increases throughout the rest of the world, and the global effects of regional shortages have been evident in the years since. The new level of worldwide economic interdependency is also reflected by the international effects of the energy crisis, inflation, monetary imbalances and stagnating economies.

The Need and the Resources

Estimates of the world's future food problem are essentially attempts to forecast potential need and/or economic demand for food, and to compare it to potential production and/or economic supply. Such estimates obviously are influenced by important unknowns and assumptions, involving not only such factors as food output and population growth but less direct influences such as technological development and government policies. Hence, the vast differences among various forecasts by both scientific and popular spokesmen. However, certain recent studies of the food problem that are both broad in scope and

detailed in analysis seem to be in reasonably close agreement--at least in regard to overall trends and possibilities.

Several such studies are the basis for this chapter. They include reports by the Economic Research Service (ERS) of the U.S. Department of Agriculture (USDA) (5), the University of California (4), and the FAO (3). Other documents, including a provisional report of the World Food Conference held in Rome in November 1974 (1), also provided information. Most of the following material, even when specific references are absent, comes from these sources.

Generally stated, the conclusion of these reports is that widespread disaster can be avoided if certain actions are taken and the weather cooperates reasonably well. But these projections--specifically, those of the USDA and the University of California--are largely limited to the next decade. This may be one reason for possible misunderstanding of these conclusions, compared to those of apparently more pessimistic observers. These reports do not deny the danger of global famine within the lifetime of many persons now living. They point out, however, that the potential for extreme variation--both good and bad--in the controlling factors after 1985 is virtually unpredictable.

The world's need for food at any time may be considered in terms of nutritional requirements or in terms of market demand. Obviously, these two types of "need" will not necessarily be at the same level under any particular set of circumstances. It should be kept in mind that significant malnutrition may exist even though market demand is satisfied, especially at high price levels. (U.S. public policies to provide food assistance to the needy in this nation and overseas are detailed in Chapter 5.).

In any case, mankind's total demand for food will be determined by three factors--the number of people in the world, their individual incomes, and their food preferences and customs. These factors interact with supply to determine both market prices, and the actual amount of food the world's population will consume.

Trends in Population and Income--In 1973, world population was estimated at 3.8 billion, having increased about 1 billion in only 16 years. At present, world population is growing at about 2 percent each year. Using varying assumptions regarding future fertility and mortality, United Nations demographers have developed three possible world population projections to the year 2000. The high possibility is 7.1 billion, the medium about 6.5 billion, and the low 5.9 billion.

Equally significant is the difference in growth patterns between developed and developing regions of the world. In the former,

population growth rates have declined to less than 1 percent annually. The rate is more than 2.5 percent in the developing regions, which now contain more than 70 percent of the world's population and are producing close to 90 percent of the annual increase (5).

There is a crucial difference between underdeveloped regions which are densely populated (India, Indonesia), and those with less population and more unused resources (South America, Africa). Hence, the problem of meeting food needs varies greatly according to region, and is more severe in those parts of the world where population density already is high, where growth rates are not under control and where resources are almost fully utilized.

Total demand for food is determined largely by population level, but individual consumption depends on level of income and, in the case of rural populations, ability to grow their own food. In most countries with low average per capita incomes, half or more of that income is spent for food, compared to less than one-fifth in the more affluent nations. Market demand for food may be greater or less than the amount needed for adequate nutrition, depending largely on individual income level.

Distribution of income is a crucial factor. Very poor nations, with average incomes of \$100 or less, tend to have more equal income than those at a slightly higher level. The most inequality of income is found in nations with \$200 to \$300 per capita average income. As average incomes rise toward the \$1,000 or \$2,000 mark, there is a tendency toward more economic equality (5).

An important factor influencing income levels is inflation, which is particularly hard on poor people who spend a larger proportion of their income on food and shelter.

Both income and cultural preferences influence the type of food consumed by human populations. A central factor in evaluating the world food problem is the necessity for many low-income populations to depend largely on cereal grains. The World Bank, which defines a low-income country as one with less than \$200 per capita gross national product, points out that about two-thirds of the world population lives in such countries. For these people, the food problem will continue to be primarily the availability and price of grain (5).

Allowing for the above uncertainties and others, the University of California report projects future per capita consumption trends and total consumption (market demand) for 1985, assuming the medium population figure forecast by the United Nations.

The projections show patterns of future per capita food demand differing widely in various parts of the world. High-income countries show a marked increase in projected individual demand for vegetables, fruits and meat in 1985, but a decrease in wheat, roots and tubers, eggs, and animal fats and oils. Developing countries, such as India, show projected per capita increases in almost all kinds of food.

By adding expected increases in per capita consumption to increases in demand resulting from future population growth, total consumption of various commodities can be projected. The University of California report compares those projections to the 35 percent population increase expected by 1985 and concludes that demand for all but two major crops will increase even more than population. Wheat and roots/tubers are the exceptions. Demand increases of from 36 percent to 50 percent are projected for rice, coarse grains, oilseeds, vegetables, eggs, milk, and fats and oil; and from 51 percent to 63 percent for sugar products, pulses and nuts, fruit, meat, and fish. The larger increases are for foods that generally are consumed more as incomes rise (4).

The report's demand projections for various commodities naturally are much higher for the year 2000 than for 1985, but the trends appear similar. Food demand estimates for 2000 differ significantly, however, with whether high or low estimated population trends are used. For instance, the low population estimate by the United Nations indicated a 68 percent increase over 1970 in effective demand for cereals, while the high estimate points to a 100 percent increase.

Resources to Meet the Need--Virtually all human nutrients come from three sources--crops, animal products (meat, milk, eggs), and aquatic foods. Of these three, crops are by far the most important. They furnish over 90 percent of the human population's calories and about two-thirds of its protein. The remainder of the protein comes from livestock, poultry and fish.

Among crops, the cereals (wheat, rice, maize, millets, etc.) occupy three-fourths of the cropland area and provide about that same proportion of the world's calories (see Table I). Root crops, oilseeds and sugar provide about 20 percent of the calories from crops. Vegetables and fruits satisfy only a very small proportion of calorie needs, but are very important for other nutritional values.

The ultimate limits on food production from these sources are set by the availability and quality of natural resources--chiefly land and water--and by weather. Food production levels also are determined by the supply of energy, by the level of technology, and by economic forces, governmental policies and customs. Projections of future

crop, animal, and aquatic production depend on estimates of all these factors, some of which obviously are easier to evaluate than others.

Arable Land and Water--It has been estimated that the world has somewhat more than 3,000 million hectares of potentially arable farmland (cultivable acreage which would be reasonably productive of adapted crops) and that only about half of that amount is presently being farmed. There are, however, serious problems to be faced in developing the remainder.

The USDA report points out that, although the world as a whole clearly is not running out of land, there are serious regional problems in development and also unequal distribution of potentially arable land throughout the world. Most of the world's people live in nations where there is little possibility of expanding the cropland area. India, Bangladesh and Egypt are examples. However, in Latin America and Africa significant amounts of land could be developed (5).

According to the University of California report, if all potentially arable land in the world were cultivated, with productivity at the 1970 level, almost 8 billion people could be given an adequate diet. But the report points out that "it is a logical assumption that land not now cultivated will be generally inferior in productivity to land presently in use for crops" (4).

Some of the problems involved in bringing new land under cultivation are its remoteness, lack of capital, lack of transport and agricultural industries, and the need for research to solve localized production problems. Nevertheless, there are some promising areas. The Amazon and Congo basins, for instance, are sparsely populated but contain about 300 million hectares of potentially arable soils with abundant rainfall. Surrounding these basins is almost as much additional land with a dry season up to six months long. These lands total almost 800 million hectares. The principal soils are low in fertility and organic matter and undesirably high in iron and aluminum but are smooth and adequately watered. Productivity is so low in some areas that sustained production is not possible with presently known technology, but the University of California report assumes that research could overcome that problem--if demand and prices provide the incentive (4).

Possibilities for irrigation include both development of new irrigation projects, and more efficient use of water on presently irrigated acres. In its proposals prepared for the World Food Conference, the FAO stated: "The returns obtainable by a thorough overhaul of the world's facilities for irrigated agriculture would be enormous. A

large number of irrigation schemes are operating at less than 50 percent efficiency and the doubling of staple food crop yields, such as cereals, with improved management of the necessary inputs is perfectly feasible in many areas...the developing world has, in all, about 93 million hectares of land equipped and capable of being irrigated..." (2).

In addition, substantial development of new lands for irrigation is possible, but will be costly. One estimate is that only 200 million hectares out of 344 million hectares of irrigable land are presently receiving water. However, further development is estimated at an average of \$1,200 per hectare (4).

It appears that on a worldwide basis, enough potentially arable land is available to meet food requirements until 1985 and beyond. Europe, USSR, North America and Oceania have adequate land and the technology to farm it. South America and Africa have vast undeveloped land and water resources, but probably lack capital and other resources to bring them into production without outside help. Asia, however, presents a different kind of problem. In the words of the University of California report: "Asia will have 58 percent of the world's people by 1985 but only 20 percent of the potentially arable land. It does not seem possible for Asia to supply its food needs without (a) a sharp drop in population increase, (b) large-scale migration of people, or (c) intensity of land cultivation much greater than at present" (4). To these alternatives, of course, must be added the possibility of vast transfers of food from elsewhere in the world.

Climate and Weather--A region's climate--its long-range temperature and precipitation patterns--generally is much more stable than the short-range fluctuations of its weather. The problem of the effects of climate and weather on the world's food supply, therefore, has two aspects: (a) the possibility of long-range changes in climate, and (b) the certainty of year-to-year variations in weather, causing shifts in crop production locally or regionally.

"Although the effects of weather and climate on crops can be modified to some extent, most of the world's food supply still depends on the weather. Some regions--Oceania, Canada and the eastern portions of the USSR--experience quite wide fluctuations in production from year to year. Other regions--Europe, the United States, much of Latin America, Africa and Asia--experience generally consistent weather patterns..." (5).

Speculations regarding long-range changes in the world's climate arise from several sets of observations: (a) evidence that major changes in global climate have occurred in past eras; (b) the warming up of the northern hemisphere from the late 1800's until the middle of this century (about 0.6 degrees Centigrade),

followed by a cooling trend since the 1950's (about 0.3 degrees); and (c) the dumping of wastes and pollutants into the atmosphere by man's activities.

Because of the unknowns and possible offsetting effects of various influences on the earth's climate, it appears almost impossible to forecast effects of long-range climatic trends on worldwide food production with any certainty. What can be predicted is that short-range effects of weather will be felt and that their impact could be very serious. The degree of danger may not be apparent because the modernization of agriculture has taken place during a period of relatively few extreme short-range variations in weather. In India, for example, rainfall was below the 50 percent-of-average level only once in 15 years at mid-century, compared to once every four years a few generations earlier. In effect, the University of California report says, industrialized agriculture has "tuned itself well to the average climate in a time of limited variability" (4).

Furthermore, modern agriculture is more vulnerable to weather extremes for various reasons: (a) more intensive land use, thus exposing more production to local extremes, (b) more farming of marginal lands, and (c) crops bred to fit specific conditions. However, today's farmers can react more quickly to weather changes by planting new lands, changing crop varieties or making use of other technologies.

Projections of food output generally assume "normal" weather, recognizing, however, the possibility that weather conditions could be either more or less favorable than normal. In the words of the USDA report: "This underscores the need for flexible world food policies to adapt to changes in conditions and to provide a margin of security against sudden or unexpected changes" (5).

Energy Supply--The potential effects of recent petroleum price increases on energy-short, undeveloped nations are well known. It should be emphasized, however, that energy supply is particularly important at certain stages of agricultural development. One such period is when significant numbers of farmers are shifting away from subsistence agriculture toward more specialized, labor-efficient and possibly larger production units. At this point, a transportation network and inputs of fertilizer--both highly dependent on energy supply--are crucial.

The impact of fossil fuel price increases will affect developing nations in different ways. The University of California report points to four groups: (a) the oil-exporting countries of the Middle East and Latin America who obviously will benefit; (b) those nations that do not import much fuel or energy-related products, hence, will

not feel much effect (People's Republic of China, Columbia, Mexico, Bolivia, Brazil, Equador, Peru, Malaysia, Morocco, Tunisia, Zambia, Zaire); (c) certain nations closely linked to, and therefore adversely affected by, economic stagnation in industrialized nations (Greece, Spain, Turkey, Yugoslavia, Algeria); and (d) about 40 developing nations in tropical Africa, South Asia, and the Central America-Caribbean area which will be hardest hit.

Effects of the energy crisis on developed nations have been both dramatic and highly complex. In the food sectors of the developed economies, two crucial effects have been higher prices for fuel and fertilizer and drastic changes in international trade balances.

An additional point: The highly energy-dependent food production system developed in the United States and Europe would not be suitable for most developing nations even if fossil fuels were plentiful and cheap. Many less developed nations possess large quantities of under-utilized labor. It is important that their agricultural production systems require less inanimate energy and more labor energy than those of the United States and other developed nations.

Yield-Increasing Technology--Of the chief factors that will determine future output of the world's food, the supply of land and water probably can be evaluated most accurately since it is somewhat less vulnerable to the vagaries of nature and human behavior. However, the potential of yield-increasing technology also can be anticipated with some degree of confidence by considering (a) likely new technological development growing out of research, and (b) the expected impact of existing technology as it is transferred, with appropriate adaptations, to developing areas.

All recent studies of the world food problem conclude that future increases in yield will contribute far more to expanded food output than increases in cropland area--except possibly for Latin America and Africa--where more undeveloped land is available (5). Nevertheless, as experience with the "Green Revolution" has shown, the transfer of technology to developing food production systems is a complex process with unexpected problems.

For one thing, traditional agricultural systems have used crop varieties that are tolerant to problem soils, pests, and other environmental stresses, even though their yields are low. In many cases, these varieties also make efficient use of the resources readily available. Under these circumstances, if yields are to be increased significantly, various kinds of new technology must be introduced simultaneously. For instance, use of fertilizer on traditional crop varieties may produce little economic result; but if new varieties with high yield potential are introduced, fertilizer use may become a crucial bottleneck.

The principal types of yield-increasing technology are fertilization, pest and disease control, improved varieties of crops and livestock, mechanization, and certain cultural practices such as double-cropping.

Fertilization. In 1970, the average fertilizer application rate in developed nations was over 77 kilograms per hectare, compared to 14.5 kg/hectare in developing areas. There is no doubt that vast amounts of fertilizer will be needed by the developing nations; but in view of the fossil fuel crisis, its availability and price are important unanswered questions.

Pest and disease control. Reducing losses to pests and diseases, in both crops and animals, is one of the most promising ways to increase food output in many parts of the world. Worldwide crop losses to insects and other pests, diseases and weeds are estimated at one-third of potential production even before harvest. Additional losses in storage vary greatly, but can be staggering--the estimated loss of stored grain in India during 1962-64 was about a million tons more than the total amount of grain imported (4). Even at the level of known technology, pest control methods have tremendous capability for reducing these losses.

One important need is to develop pest management programs by combining other control methods with chemical pesticides, which remain "in many situations a most powerful and dependable tool for the management of pest populations...indeed, use of chemical pesticides is presently the only known method for control of many of the world's most important pests of agriculture and public health" (4).

Two problems associated with the opportunity for increasing food output through pest and disease control are (a) the increase in susceptibility to pests and diseases caused by intensive farming of large areas with uniform crop varieties, and (b) hazards to safety and the environment caused by pesticides, especially misuse or over-use of pesticides. The worldwide problem of pesticide resistance is a related difficulty.

Plant and animal improvement. The spectacularly higher-yielding varieties of wheat and rice associated with the Green Revolution illustrate the vast possibilities, as well as the problems, of introducing new and better varieties of food crops. The potential for more output is tremendous. However, it is necessary to adopt the new varieties as part of a package of new farming practices. For instance, the required fertilizer may cost a good deal more than the new, high-yielding seeds. If that happens, the farmer may for valid economic reasons decide to buy less fertilizer and settle for a somewhat smaller crop. But if any of the inputs is lacking, the potential of the new varieties almost certainly will not be realized (5).

Improving livestock, primarily by increasing the efficiency of feed production, feed conversion, and reproduction, is another promising way to increase world food output. Again, vast improvements are possible with known technology. Productivity of livestock probably could be significantly increased with relatively small investments of energy and other resources.

Other technical inputs. Irrigation, mechanization and cultural improvements are other ways to increase food output. In each case, significant potential is unquestionably there. The problems include need for capital and need to adapt the new methods to the particular conditions of the locality or region.

Policies, Institutions, Traditions--The world's future output of food also will be determined in part by the economic forces, regulations, arrangements and customs that control food production and distribution systems. Institutional bottlenecks--as well, of course, as institutional strengths--exist within developed and developing nations and on the international scene. Among the areas requiring attention are income level and distribution; prices and marketing arrangements; international trade policies; land tenure and land use; and research and education.

Trends and changes in policies, institutions and traditions are, of course, difficult to predict. In estimating future world food supply, the effects of these factors will be, at best, estimates and assumptions. Yet the fact that human attitudes, habits, and procedures can and do change is one of the more hopeful aspects of the worldwide food problem.

Prospects for the Future

The needs and the available resources include a growing world population with rising expectations; limited but apparently adequate land and water; largely unpredictable weather; increasingly costly energy; the relatively certain potential of technology; and the relatively uncertain effects of economic forces and human institutions. Given these factors, what is the outlook, short-range and long-range, for an adequate diet for the human race?

Within the past year, projections of future food supply and demand have been made by the FAO, by the USDA and by the University of California (1,3,4,5). These agency reports are fairly specific about the next decade--until 1985--but for obvious reasons are somewhat vague about the years afterwards.

A major conclusion is that, on a worldwide basis, food supply and demand projections for 1985 balance reasonably well. Oilseed and some animal products may be in short supply, but only because of

high demand in the more affluence countries. For major crops such as wheat and maize, total worldwide economic requirements for human food, animal feed, processing losses, etc., will be generally in line with gross production. (Nutritional requirements, of course, may well differ.) A slight economic deficit, estimated at 2 percent, is projected for rice (4).

However, the assumptions behind these projections are crucial. These assumptions are: First, that world's population will increase by no more than 2 percent yearly on the average. Second, that total yearly output of basic crops will continue generally upward, as a result of increasing cropland area and, more important, higher yields per hectare. The assumption of increasing output, in turn, rests on two others: That worldwide weather patterns will not change drastically for the worse and that food production and distribution technology will continue to improve as a result of research and education in both developed and developing countries.

A second major conclusion is that, in spite of the outlook for global supply-demand balances for food in 1985, serious regional imbalances are likely. One important factor will be regional weather patterns. Others, more within man's control, will include (a) effects of the energy crisis, and (b) trends in worldwide food distribution, determined by prices, world trade patterns and food aid programs. There is a clear possibility of malnutrition or famine in some parts of the world at the same time that excess food, or at least excess food production capacity, exists elsewhere. The FAO projections "stress the growing dilemma of grain surpluses in developed countries and rising deficits in many developing countries, particularly South and Southeast Asia" (5). The USDA report points out that its projected increases in future consumption assume that developing nations will either be able to earn foreign exchange to pay for increased imports of food, or the food will be made available under special arrangements of some kind (5).

Potential surplus production of grain in North America and Oceania probably would be sufficient to make up the vast deficits of the developing countries in 1985--"provided of course that the developing regions have the monetary resources to purchase the grain and/or the developed countries are willing to give it outright or provide it on a concessional basis" (4).

One important question is whether the developed nations continue to rapidly expand their output of grain-fed livestock. The USDA report says that "if consumption of animal protein in developed countries rises only moderately, world grain exporters would have no serious problem meeting world import demand" (5).

All these projections are limited to the next 10 years or so. Beyond 1985, there is more potential variation in certain trends--particularly population increase. None of the reports predicts a worldwide food emergency by the year 2000, but by that time it appears more likely. On the other hand, crucial factors such as population growth and food output conceivably could vary in a favorable direction. It is not impossible that by the year 2000 the problem of a hungry world could be managed and under reasonable control.

Actions That Can Shape the Future Situation

The outlook for feeding the world during the next decade and beyond reflects the various knowns, unknowns and assumptions already discussed. Some of these factors, such as the supply of potentially arable land and long-range climatic trends, are not presently under man's control. Other factors, however, can be significantly influenced by human decisions and actions. The more important of these listed in the reports by FAO, USDA and the University of California fall into five categories: (a) population policies, (b) resource use and consumption patterns, (c) research and education, (d) political, social and economic organization, and (e) international trade and food reserves.

Population Policies--The world population is approaching 4 billion and could be over 7 billion by the year 2000 (the highest FAO alternative projection). Although the population growth trends for the next decade or so are virtually predetermined, the best hope for a downturn in growth rates before the year 2000 is action now. Spokesmen at the World Food Conference pointed out that:

Although it was clear that the food needs entailed by inevitable population growth must be met, it was equally clear that population could not indefinitely continue to double every generation, and that at some point the earth's capacity to sustain human life would inevitably be overstretched if present trends continued (1).

One hopeful trend may be developing in the People's Republic of China, where--according to recent reports--population growth apparently is being checked by a combination of birth control education, social pressure and economic incentive. Other densely populated nations whose governments have diligently attacked the problem of family planning have shown downward trends in population growth rates. This problem, though difficult, can be solved.

Resource Use and Consumption Patterns--Vast land resources are available for development, and even greater possible gains are promised by irrigation development and improved water use. Tremendous savings could be realized by controlling crop losses in the field and in storage, and in controlling animal diseases. In addition,

it is possible to reduce many indirect forms of waste such as poor cropping intensities; loss of land, water and fertilizer through plantings of poorly adapted crops; poor irrigation management; and inefficient harvesting (4).

Consumption patterns, particularly in the grain-livestock sector, also can significantly influence total world food availability. As the USDA points out, increased consumption of grain-fed animal products in the more affluent nations could cause shortages of grain for human consumption in the developing countries (5).

However, even if grain feeding is reduced or eliminated, livestock will remain an important source of human food. This is because, even though plants yield more protein and calories per cultivated acre than animals, there are other important considerations: (a) Livestock can utilize vast areas of grazing lands where high-yielding crops will not grow; (b) livestock and poultry consume fibrous feeds, wastes and byproducts that otherwise would be wasted as food; (c) plant and animal roles in the world's farming systems are traditionally complementary and interdependent; (d) animal foods, of high nutritional quality and relished by most peoples of the world, are an efficient means of improving human diets (4).

Research and Education--Training programs, technical assistance and national, as well as international, research institutes all are promising ways to boost food production. Programs of education and research organizations must be designed to produce practical solutions that can be applied widely and rapidly. Direct technical assistance by overseas experts has proved very valuable at times and should be continued where the level of technology is fairly high. However, success in the long run will depend on well-trained and well-motivated corps of native extension and research workers (4).

Political, Social and Economic Organization--In this category are a multitude of reforms and changes suggested to reduce poverty, provide credit to farmers, enlarge and improve marketing systems, create incentive for specialized farm production, etc. Land reform and rent control, increased economic size of small holdings, publicly-supervised production credit systems, small-farmer cooperatives, and better education, health care, transportation and communication--these measures, in the words of the University of California report, "have, in fact, brought about agricultural progress in industrialized countries and are doing so now in Taiwan, Malaysia, China and Mexico" (4).

International Trade and Food Reserves--Opening world markets to developing nations, so that they can earn the income needed to feed their populations and to continue their economic development, is a

central problem. International food aid programs involving direct grants or concessional sales unquestionably will be needed, but unless they are carefully planned and managed they may inhibit the receiver nation's economic growth (4).

Another major policy question is whether developed nations, whose grants of food aid during the 1960's were tied in with surplus disposal programs, are willing to continue that aid in a period of high prices and food shortages (5).

The question of worldwide, managed food stocks or reserves also is fundamental. Such stocks could have two purposes: as emergency reserves against the threat of famine, and as a management device to lessen the extreme fluctuations in world food prices. The FAO has proposed a plan calling for (a) adoption of national food stock policies and establishment of national targets, (b) an improved system of worldwide information exchange on food availability and (c) expansion and coordination of assistance to developing countries (5).

Role of the United States--The United States has two major capabilities for helping to solve the world food problem--capacity for surplus production and advanced technical ability for production and distribution.

Surplus food production, if it materializes in the years to come, could affect (a) domestic prices, (b) international aid programs, and (c) the potential world food reserve system. If the necessary commitments are made on the international level, it is certain that the U.S. will play a major role in the development and maintenance of a world food reserve system. In fact, it is likely that a large part of the surplus stocks going into such a system will be provided by the U.S. either directly or through other nations who purchase their contributions from us.

The technical expertise possessed by the U.S. could be of great help in reducing chronic food shortages in many regions. However, more students need to be trained in such areas as environmentally adaptive and cost-efficient technologies; systems that can be applied to small production and marketing units; high nutrition, low bulk foods and feeds; optimal intranational and international trading patterns; and institutional systems in support of agricultural production.

United States agricultural research also will play a major if not the leading role in providing the world with the technology needed to increase yields per acre, efficiency of animal production, better use of land and water resources, or output of new foods.

Conclusion

The world food problem can be defined as the task of providing an adequate diet to the entire human population. Delegates to the UN World Food Conference in 1974 declared that:

Every man, woman and child has the inalienable right to be free from hunger and malnutrition...Society today already possesses sufficient resources, organizational ability and technology, and hence the competence to achieve this objective. Accordingly, the eradication of hunger is a common objective of all the countries of the international community, especially of the developed countries and others in a position to help. (5)

During the past three or four years, modern man has been faced with unsettling new evidence that the ancient enemy, famine, remains unconquered. However, man is no longer largely helpless in the face of his own growing needs and the capriciousness of nature. The chief manageable factors to be balanced are population numbers and rising expectations on one side; and resources, technology, and policy on the other.

There is reason to believe that, at least until 1985, serious world-wide food shortages can be avoided, although concerted action probably will be needed to prevent catastrophe in some of the world's more vulnerable regions.

Areas of possible action include population policy; resource use and consumption patterns; research and education; political, social and economic organization, and international trade. Of these, research and education probably offer the most opportunity for immediate action. In fact, progress in all areas will depend on acquisition and use of scientific knowledge.

Table 1. WORLD CROPS BY COMMODITY ACCORDING TO LAND AREA, PRODUCTION, AND ENERGY (mcal)
1970

COMMODITY	LAND AREA		PRODUCTION		ENERGY	
	Ha x 10 ⁶	%	Metric Tons x 10 ⁶	%	mcal x 10 ⁹	%
Total Cereals	698	73.5	1208	38.4	4210	74.5
Wheat	211	22.2	318	10.1	1062	18.8
Rice	134	14.1	307	9.8	1108	19.6
Coarse Grains	353	37.2	583	18.5	2040	36.1
Maize	108	11.3	260	8.3	910	16.1
Millet-Sorghum	71	7.5	64	2.0	225	4.0
Other	174	18.4	259	8.2	905	16.0
Roots and Tubers	49	5.2	551	17.5	496	8.8
Sugar Crops	19	2.0	814	25.9	285	5.0
Pulses and Nuts	60	6.3	43	1.4	147	2.6
Oilseeds	102	10.8	105	3.4	390	6.9
Vegetables	7	0.7	220	7.0	48	0.9
Fruits	14	1.5	204	6.5	76	1.3
TOTAL	949	100.0	3145	100.0	5652	100.0

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PUBLIC FOOD POLICY

Introduction

Public agricultural policy in the United States has historically been concerned with (a) maintaining reasonable and stable farm incomes; (b) increasing efficiency through research and education; and (c) coping with the increasing agricultural output of a highly productive food and fiber sector.

Programs designed to support farm incomes and to manage supplies of farm commodities have been concentrated on the major crops--grains, oilseeds, cotton--which account for two-thirds of all harvested acreage; certain other crops--rice, peanuts, long-staple cotton, tobacco--also have a lengthy history of Federal support programs. Fruits and vegetables and specialty crops such as seeds have been largely excluded from such farm programs, although they have been affected by marketing orders and agreements. Among livestock products, dairy products are the major ones covered by price support programs.

Programs to bolster farm income, particularly high price supports, necessitated programs to curtail output by controlling the acreage under cultivation. At the same time, public investment in research and extension was developing and disseminating to farmers a highly productive output-increasing technology. In the past decade, acreage restrictions and high price supports have given way to market level supports, voluntary acreage withdrawals, and direct payments to support income.

With the recently changed conditions in agriculture resulting from unusual domestic and international demands on available supplies of farm products and the resulting rise in farm income, concern about the farm income problem has abated and programs to curtail output have been superseded by efforts to expand production. The issue of food security at home and abroad has become an important policy problem. Overseas food aid and development assistance are of growing concern.

Consumers, accustomed to relatively low food prices, reacted strongly to the rise in prices that occurred after the events of 1972 and are speaking out for policies that will guarantee them adequate, stable, and nutritious supplies of food at reasonable prices. Congress has evinced a special concern for disadvantaged

groups and has instituted a number of programs to provide food assistance to low-income consumers, children, and other vulnerable groups. The desire for a clear and unpolluted environment has led to a number of policies and programs designed to protect and preserve our natural resources--but which also impact significantly on food supplies.

The policies which affect food supplies are numerous and complex. This paper is an attempt to provide a background on public agricultural, food, and research policies as they affect the capacity of the United States to meet its own and world food needs.

Domestic Agricultural Policies

Historical Review--In 1862, Congress passed legislation that led to the Department of Agriculture and also, through the Morrill Act, set up colleges of agriculture in the various States and territories. In 1887, the Hatch Act established experiment stations in connection with the colleges. These legislative and policy developments led to support for agricultural research at both Federal and State levels, which has been augmented over the years. Nearly all of the agricultural colleges have emerged as State supported general universities, and continue today as a major thrust of the American university system in biological research and teaching. Passage of the Smith-Lever Act in 1914 set up Cooperative Extension, thus adding the third component of the agricultural teaching-research-extension system.

Prior to the 1930's, U.S. policy with respect to farm prices and incomes was--except for research and education--generally laissez-faire. With the passage of the Agricultural Adjustment Act in 1933, the major new thrust of U.S. farm policy became clear: to enhance the prices received by farmers for their products and to improve their income status relative to that of workers in nonfarm sectors of the U.S. economy. The forms of intervention used to carry out these aims were price supports, acreage controls, direct payments, import quotas, and export subsidies.

Efforts to curb production were not entirely successful because the propensity to support prices often exceeded the willingness to impose parallel production controls. Government-owned stocks began to accumulate. In 1938, marketing controls were added in an effort to strengthen acreage controls. Although acreage restrictions and marketing quotas were in effect, output did not decline and yields per harvested acre began an upward trend.

A major reason for the upward trend in yields was another policy designed to increase agricultural output through programs of public investment in agricultural research, extension of new techniques,

and, in some cases, subsidization of improved practices. Limits on the use of land led farmers to substitute other inputs and contributed to increased yields. To a large extent, the technology applied by farmers to increase their output was responsible for demands on Government to support farm income (1).

The unwanted surpluses of the thirties--and, probably more important, the reserve capacity to produce--became strategic military assets for the U.S. and its allies during World War II. After the War, stocks again accumulated as farm output, stimulated by relatively high price supports expanded faster than market demand.

The Korean War provided only a brief interruption in the continued growth of surplus stocks of grains and other commodities. Government price supports were maintained at high levels for major crops throughout the 1950's. During this period, efforts to limit output and to dispose of surpluses also were undertaken. In 1954, wheat marketing quotas were reinstated, and in 1956 the Congress passed the Soil Bank Act which permitted farmers to take land out of production in return for payment. The amount of land taken out of production was never very large, nor very productive, and after 1960 no new land was retired under the Soil Bank. In the face of the continuing rapid technological advance in agriculture, those programs had little impact on output.

At the same time that programs were being enacted to curtail output, efforts were being made to dispose of surpluses. Subsidies were used to facilitate exports to commercial markets. Under P.L. 480, passed in 1954, concessional sales of wheat, feed grains, and other commodities were made to developing countries. Humanitarian food assistance in the wake of natural disasters and other emergencies was also provided for.

By 1961, despite these efforts, feed grain stocks totaled nearly 85 million tons, and stocks of wheat amounted to more than 1.4 billion bushels. The cost of storing and maintaining stocks owned by the Commodity Credit Corporation was over a million dollars a day.

In the 1960's, the move toward gearing agricultural programs and policies to market price levels began (1). Supports on feed grains and cotton were set at levels at which export subsidies were not needed, and wheat export subsidies were the lowest in years. Farmers were offered payments to voluntarily withhold acreage from production. The losses in income from lowered price supports and acreage reductions were offset by direct payments to supplement producers' income.

Early in the 1960's, a policy of high price supports with tight supply controls was proposed for wheat. However, farmers made it clear that such controls were unwanted by rejecting marketing quotas in the wheat referendum of 1963.

Current Domestic Farm Policy--In the 1970's, U.S. farm policy continued its shift away from compulsory controls and high price supports. The Agricultural Act of 1970, an important milestone in U.S. farm policy, reduced substantially the crop-by-crop acreage controls of previous years and replaced them with a general land diversion program. A farmer received cash payments for retiring his individual share of the land that needed to be taken out of production in order to balance supplies with market demand for a specified crop. Participation in the set-aside program did not interfere with the farmer's freedom to choose the crops that would maximize income on his remaining land and those farmers not choosing to participate could produce at will. In addition, participation in the set-aside program made farmers eligible for price supports.

Present farm policy embodied in the Agriculture and Consumer Protection Act of 1973 is one more step in the shift away from the commodity programs which began in the 1930's. Mandatory acreage allotments, marketing quotas, and high price supports are no longer in effect for wheat, feed grains, and cotton, although rice, peanuts, and long staple cotton continue to be covered by fairly rigid programs.

Current farm policy is based on a number of practices that are incorporated in the 1973 legislation (2). These approaches, which permit considerable flexibility to the Government in managing the farm economy have received broad support (13). Under the 1973 legislation, market prices for wheat, feed grains, and cotton are not supported at higher than market-clearing levels. Loan rates provide a floor to prices received by farmers, but are set at levels that should not build Government stockpiles very rapidly (13). Direct cash payments have replaced price supports as a means of providing income support to farmers.

A new feature in U.S. farm policy, the target price, is the instrument used to determine the amount of direct payments. If market prices fall below the target levels, farmers receive the difference between the two. Starting in 1976, target prices can be raised in accordance with rises in the cost of production to farmers.

Dairying continues to be heavily supported and protected by Federal programs. State and Federal milk marketing orders establish a higher price for fluid milk than for milk used in processing and

also restrict the movement of raw milk. Imports are usually limited to less than 2 percent of total consumption, and trade in dairy products has become a source of dispute in international trade negotiations. Dairy producers' welfare has come to depend on Federal regulation so that serious adjustment costs would be incurred if dairy programs were eliminated.

Grain Reserves--In 1972, the sharp reduction in world grain production, the large Soviet purchase of wheat, and subsequent heavy buying by other nations to insure supplies of grain and soybeans, led to a sharp reduction in stocks and a strong rise in prices. The U.S. disposed of most of its publicly-owned grain stocks by the end of 1973.

With the present low levels of stocks, it may be some time before they are rebuilt to adequate levels. Moreover, there is not only uncertainty as to when stocks will be rebuilt, but there are differences of opinion on the levels that are necessary and the type of national or international grain reserve policies that are needed for the future.

While almost everyone seems to prefer larger stocks than now exist, there is strong reluctance to return to a situation with huge surpluses accumulated by governments. The specific U.S. position regarding reserves is still in the making, but in general, the U.S. has endorsed the concept and need for reserves of a manageable size--to meet contingencies in the world. The U.S., however, favors a wider sharing of the burden of holding these reserves than prevailed in the past. There is also a feeling in the U.S. that these reserves, to the extent possible, should be held by the private sector. As a follow up to the recent World Food Conference, the U.S., with other major importing and exporting nations, will be working out the details of international grain reserves arrangements over the next few months.

Trade Policy--Agricultural trade makes a substantial positive contribution to the U.S. balance of payments. In 1972, when the deficit in the overall trade account was \$6.4 billion, agricultural products contributed a surplus of \$2.9 billion. In 1973, farm exports showed a positive balance of \$5.4 billion while the overall trade deficit was around \$3.5 billion. The importance of international trade to U.S. farmers is illustrated by the fact that over 25 percent of U.S. harvested acreage produces commodities for export. In addition to creating income for farmers, the movement of farm products through world channels of trade generates employment throughout the economy.

Trade policies and domestic agricultural policies are very closely related and in fact are mutually reinforcing. While domestic farm policies have been designed to raise or stabilize farm income, trade policies have been designed to protect domestic producers from competition by farmers abroad. When price supports are used to provide more than modest price stability, a policy of influencing international trade--exports, imports, or both--is the consequence (5).

In fact, the U.S. has pursued policies that influence or control exports and imports. However, exports of U.S. agricultural commodities confront protective barriers abroad. Domestic price support and agricultural protection policies are common to industrially developed nations where farmers' incomes have lagged behind incomes of other workers in the economy. Support and protection for grains in the European community, for instance, is based on a system of administered prices under the Common Agricultural Policy. In Japan and in Eastern Europe, State trading agencies determine prices and purchase commodities from farmers and also maintain a large measure of control over imports.

Trade Liberalization--As domestic farm policies have moved the U.S. away from high price supports, trade policy has moved upward liberalizing trade in agricultural products. The majority of tariffs authorized in the 1930's have been reduced by 50 percent or more, although high tariffs remain for some agricultural imports--dairy products, fresh and preserved fruits and vegetables, certain milled grain products, wines, and leaf tobacco.

Import quotas are in effect for four commodities: Cotton, peanuts, dairy products, and sugar.* With respect to meat products, which have been largely outside the scope of domestic farm programs, the Meat Import Act of 1964 authorizes the imposition of quotas on beef, veal, mutton, and goat meat. These were administratively suspended in 1973.

*The U.S. Sugar Act expired at the end of 1974. Quotas on raw and confectioners sugar were assigned to foreign countries to reflect 38 percent of U.S. basic sugar requirements and 35 percent of growth in domestic sugar requirements. "A Presidential Proclamation (November 18, 1974) established a global quota of 7 million short tons (raw) per calendar year. This action maintains the tariff at a rate of .625 cents per pound on raw sugar, rather than a figure that would be triple that amount in the absence of quotas. Since the quota is higher than requirements, it will not create the pressure on the market that it would if it were restrictive" (13).

Export subsidies for wheat, feed grains, and other commodities have been terminated, suspended or are being phased out, but under Section 32 of the Agricultural Adjustment Act and the legislation establishing the Commodity Credit Corporation, the U.S. could reintroduce export subsidies under certain circumstances.

Current U.S. foreign agricultural policy supports the goal of trade liberalization. This is not only because freer trade in agricultural products would facilitate more efficient allocation of resources worldwide but also because liberalized trade will permit increased exports of agricultural products for which the U.S. enjoys a comparative advantage--particularly wheat, feed grains, and oilseeds. Domestic agricultural policies which maintain prices above or below world market levels have implications for resource allocation and trade. In the current round of Multilateral Trade Negotiations formally opened in Tokyo in September 1973, the U.S. is taking the position that border protection and export subsidies should be eliminated or reduced, but that governments should be free to carry on their own farm income programs. This situation calls for greater coordination among countries in the conduct of their domestic farm policies.

A major obstacle to liberalizing agricultural trade is the adjustments which must be made, particularly by domestic producers who in the absence of protection would not be able to compete with foreign producers. The Trade Act of 1974, which gives the executive broad authority in negotiating the reduction, elimination or harmonization of tariff and nontariff barriers to trade, also provides for relief and assistance to domestic producers who must make substantial adjustments in the face of increased imports of competing products.

Other Domestic Policies That Affect Farm Production

Most public policies in agriculture in the past have been designed to support farm income or to increase farm output. However, in recent years policies that affect agriculture have been adopted to protect other interests, e.g., health, soil conservation, food quality. Concern for a clean and unpolluted environment has led Congress and various agencies and departments to more closely examine the issues and to look for ways of increasing food production while accomplishing environmental goals as well.

Public policies which tend to impact on food supplies flow from Federal or State laws and corresponding judicial interpretations and administrative regulations and procedures. Policies that affect agricultural production include regulations governing water and land use, pollution and waste disposal; regulations, standards and licensing of farm products or agricultural inputs; food assistance

programs; taxation, credit, subsidy, and insurance policies; and policies relating to transportation of farm goods. Policies which impact on the cost of fuel, fertilizer, pesticides, insecticides, and other chemicals also must be weighed.

Pesticides--Farmers have long used pesticides to control insect and pest populations that destroyed crops or rendered them unsuitable for marketing. Historically, restrictions concerning chemicals were to protect the farmer by assuring him of the quality and quantity of agricultural chemicals used as farm inputs such as pesticides, insecticides, herbicides, fertilizers, and veterinary drugs. More recently policies and programs have been undertaken to protect consumer and environmental interests. Statutes give the Environmental Protection Agency (EPA) authority to classify chemicals for restricting their use, specifying labeling, and regulating the use of those which pass through interstate commerce. A partial or total ban can be placed on any chemical or other pesticide, providing the action does not cause undue risk to the public health or welfare.

A related policy which impacts on food production is the so-called "Delaney Clause" of the Food, Drug and Cosmetic Act which provides, "That no additive shall be deemed safe if it is found to induce cancer when ingested by man or animal." The most well known drug in question is diethylstilbestrol (DES), a synthetic hormone, which has been used in feeder cattle to increase weight gain. Currently, the use of DES in cattle feeding is temporarily enjoined by court order, and it possibly will be banned ultimately.

Fertilizers--Laws have provided the farmer with accurate identification of ingredients in the fertilizer he purchased and assured him of its quality. However, regulation of the use of fertilizer to prevent more rapid eutrophication of lakes and even human health hazards caused by runoff and leaching of excess nitrogen fertilizer is more recent. Most phosphate pollution comes from detergents and sewage with only 25 percent coming from agriculture. The National Academy of Sciences in a 1972 report called for increasing precautions on the use of the 7 million tons of nitrogen fertilizer used each year in agriculture (7).

Water and Air Pollution--Significant pollution occurs from farm animal waste particularly in areas where there are large concentrations of animals in a small area such as poultry and beef feedlots (16). Legislation and regulations in this area from both Federal and State levels have generated considerable controversy over the degree of compliance.

Pollution legislation dates from 1899, but farmers were exempted until 1971 when the Refuse Act of 1899 was revived by EPA and applied to farmers as well as others. This law called for a permit before discharging waste into a waterway.

In 1972, the Federal Water Pollution Control Act Amendments (PL 92-500) were enacted which called for the elimination of the discharge of pollutants into navigable waters by 1985 and improved water quality by 1983. EPA was authorized to continue the permit system under the National Pollutant Discharge Elimination System (NPDES).

The Clean Air Act of 1972 contains provisions which the courts have interpreted to mean that "clean air area should not be allowed to deteriorate significantly" (Ruckelshaus vs. Sierra Club No. 72-08). The concept of "no significant deterioration" is a highly controversial one, with the States and agriculture generally favoring the doctrine and industry opposed. The dangers to agricultural production are set forth in a study of air pollution on damage to vegetation by the American Chemical Society in 1973 in which it is asserted that some crops cannot be grown in polluted air from urbanized areas and in others losses in growth rates and yields up to 50 percent are reported (10). USDA testified before a House Committee that estimates put the loss to agriculture from the effects of air pollution at \$500 million annually (11).

Labor Policies--Labor has had a voice in public policy, particularly in industrial production. Seasonal and casual workers in agriculture are now exploring unionization and collective bargaining for higher wages, fringe benefits, and better living conditions. Considerations of social justice and equity have led to increased public support for the demands of hired farm workers. Consequently, changes in these policies can be expected and will impact on farm output through increased costs of production, the possible elimination of some marginal operations and even increased dependency on foreign imports in certain areas.

Land Policies--The availability of good agricultural land at reasonable costs may be an increasing constraint in the future as more and more potential farm land is taken for public and nonpublic uses. Federal and State governments are moving to protect certain coastal areas, estuaries, flood plains, ecologically endangered land and various other land classifications--although some of these actions will protect farm lands. Highways, residential sites, shopping centers, industrial plants, and various other commercial and recreational uses eat up potential farm land.

Increased yields per acre have had a partially offsetting effect so far. Furthermore, the Bureau of Reclamation and the Agricultural Conservation Programs of the Federal Government have helped maintain the availability of land for farm use. However, in the future, pressures for agricultural production and the reduction of available land for farming expansion may become a significant policy issue.

Transportation Policies--Transportation and regulations concerning transport impact heavily on the agricultural sector, which accounts for 15 percent of the fuel used for total transportation. Significant savings, improved service, and reduced inefficiencies are possible if regulatory authorities, transport firms, and labor unions cooperate.

Most of the regulations which impact on the movement of agricultural products derive from rulings by the Interstate Commerce Commission and individual States. These rulings cover competitive rate structures, traffic regulations, and regulations on backhauling, routing, and load size.

Energy Policies--While agricultural output has doubled since 1949, the energy it requires has quadrupled. In 1974, the farming sector worked 354 million acres, each acre averaging 22 gallons of petroleum fuel. Recognizing the increased demand for farm production and the fact that a reduced supply of energy could jeopardize higher yields, the Administration and Congress have asked the Federal Energy Administration to give special high priority to the food and fiber sector.

The Federal Power Commission's regulations governing interruptible contracts and future supplies of natural gas could impact on food production. About a third of the food industry's energy units come from this source. Natural gas also is the feed stock for nitrogen fertilizer so necessary to good farm yields. A recent FPC study projected dim prospects for the natural gas supply by 1990 and some meat processing firms were alerted to the need to secure alternative sources of fuel by 1978.

Domestic Food Policies

Government and private studies show that, despite the fact that the U.S. has more and better food than virtually any other country, our total population is not especially well nourished. Both the Congress and the President commissioned studies into this area and several programs have evolved or expanded as a result. The consumer has become increasingly more aware and mobilized.

Since 1906 when Congress enacted legislation banning the sale of food that is "filthy, putrid, and unfit for human consumption," an

enormous number of laws to govern the quality of domestic food supplies and ensure its wholesomeness and safety have been enacted. U.S. food standards are probably the highest in the world.

However, in other areas of public policy on food, consumers increasingly have felt that their interests are not being properly represented and have demanded a stronger role in the decisionmaking process. Consumer groups are proliferating. Various departments and agencies, many for the first time, have offices that specifically represent the consumer. In 1973, the Department of Agriculture established the position of Special Assistant to the Secretary of Agriculture for Consumer Affairs.

Food and Farm Product Grades and Standards, and Food Labeling--Under the Agricultural Marketing Act of 1946 and related statutes, USDA issues grades and standards for some 300 food and farm products, and provides official grading services--often in cooperation with State and local officials--to those who wish to establish official certifications for products or who desire product control. Though useful to consumers, this is not primarily a consumer service, but rather a service to wholesalers who want to establish a uniform language about quality.

USDA grade standards for food are voluntary. However, since quality affects price, these grades establish value and are extensively used throughout the wholesale industry. USDA labels ensure the same quality throughout the country and define levels of quality for various foods.

Some standards are mandatory. The Federal Meat Inspection and Poultry Products Inspection Act allows USDA to set requirements for all products from meat and poultry, usually canned or frozen, and regulates all the labeling of products containing more than 2 percent meat.

Food and Drug Regulations--The most widely known U.S. consumer food policies are probably those designed to ensure wholesomeness and protect the population from health hazards. In this area the USDA cooperates with several other agencies, particularly the Food and Drug Administration (FDA). Most of these activities are authorized under the Federal Food, Drug, and Cosmetic Act of 1938 and its various amendments which provide that food must be pure and wholesome, safe to eat, and produced under sanitary conditions. FDA is empowered to enforce the regulations.

FDA's Bureau of Veterinary Medicine regulates drugs or other chemicals which might get into food-producing animals or into meat, milk, or eggs. Human health hazard is the standard used. USDA cooperates by constantly checking and monitoring food to ensure that it does not have too high levels of chemical residues.

Food Labeling--Labeling has become increasingly important in an age of fabricated foods, highly processed products, synthetics and away-from-home eating. Over 35 percent of all American meals are eaten away from home. If one counts food that is partially prepared, the heat-and-serve variety, the proportion of food that requires labeling is indeed significant (3).

The FDA applies three mandatory standards to such foods: quality, fill of container, and identity. If the product fails to measure up to the standards set by FDA, the label must carry the statement "Below Standard" and indicate which of the three categories has a deficiency. Since vendors do not like to place a product on the market with a "Below Standard in ..." label, these rulings have encouraged producers to improve their product. Although USDA standards are not required, if they are used to misrepresent, FDA can prosecute under the Federal Food, Drug, and Cosmetic Act.

FDA and Nutrition Labeling--Nutrition labeling has been introduced to encourage producers to improve the contents of their packaged products and to aid consumers in analyzing products. Nutrition Quality Guidelines for several food products or meals have also been issued by FDA which aim at establishing a basic level of nutritional value for a certain food class.

The controversy over labeling a food product as "imitation" has had an interesting history. FDA rulings have called for the word "imitation" to appear on the label of products designed to replace another, more established product. The White House Conference on Food, Nutrition, and Health recognized that such foods might be as nutritious or more so than the product they were intended to replace--and that real question should be safety and nutrition. FDA has proposed that the label "imitation" be placed on these items only when the nutritional quality is not equivalent.

Food Assistance Policies and Programs--Food to recipients of welfare programs began in the 1930's as a means of disposing of commodities accumulated as surpluses under the various farm programs of price support and surplus removal. A Food Distribution Program was established under provisions of the Agricultural Act of 1949. This authorized the USDA to donate commodities previously acquired by the Commodity Credit Corporation to the States for welfare programs--provided that the market prices were not endangered.

In fiscal 1974 the Federal food commodity program was reduced in size and amount as more States and localities replaced it with the food stamp program as a means of providing for their needy citizens. During that year, Federal costs of the commodity program were \$189.3 million, a decline of 21 percent from the previous year.

The food stamp program comprises the largest portion of the USDA budget currently and is the fastest growing welfare benefit program. This program, initiated on a pilot basis in 1961, was enacted into law in the Food Stamp Act of 1964. It is designed to permit families to buy the food required to achieve an adequate level of nutrition. Program participation increased from 50,000 in 1961 to 3 million in 1969 to more than 17.1 million in February 1975. This dramatic increase was a result of several factors--phasing out of the food distribution program, the rising unemployment rate, and a mandate to extend the program and provide information about eligibility nationwide.

The program has been the most popular form of food support with participants. Congress has stipulated that the Food Stamp Program should be available to all needy citizens and that food stamp benefits should be reappraised twice each year to keep up with food price changes.

Recipients received \$4.7 billion worth of food stamps for \$2 billion in 1974, which was up 27 percent over the previous year. The average benefit was \$17.54 per person per month, which amounted to a food bonus of \$2.7 billion in food benefits--a 20 percent increase over 1973.

Congress has established several child feeding programs to ensure that children receive some nutritionally sound food on a regular basis. This is accomplished through providing cash and commodities assistance to State and local authorities who set up and administer food services for children in public or nonprofit private schools, child care centers, settlement houses, summer day camp, and recreation centers. These programs have reported such benefits as a decrease in school dropouts, improvements in learning ability, better health, and increased emotional stability.

In fiscal 1974 some 4.4 billion meals were served, of which 4 billion represented the National School Lunch Program, the largest of the child feeding programs. Of the total, 1.9 billion were free or reduced price for needy children. The value of the total food used in the cooperative Federal-State programs was \$1.9 billion of which 17 percent was donated commodities. The number of needy children receiving free or reduced price meals in 1974 was 9.4 million--nearly three times the number in 1968.

Agricultural Research Policies

A major objective of U.S. public policy toward agriculture has been to increase agricultural efficiency and/or output. This has been accomplished largely through public investment in agricultural research and extension of new techniques. Public policy to increase agricultural output through a program of mission-oriented research appears somewhat contradictory in light of public policies to raise and stabilize farm income by limiting output through acreage diversion programs. The record of the past 40 years shows that policies in support of efficiency and output-increasing research have been more successful than policies to restrict output by controlling the area in production.

Public agricultural research in the U.S. began with establishment of the Department of Agriculture in 1862. Although the land-grant universities were established under the terms of the Morrill Act, also in 1862, public policy in support of university agricultural research really began with the Hatch Act of 1887 which created the State experiment stations. It provided:

"That in order to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science, there shall be established, under direction of the college or colleges or agricultural department of colleges in each State or Territory established, or which may hereafter be established... a department to be known...as an agricultural experiment station."

The Hatch Act was supplemented by the Second Morrill Act of 1890, the Adams Act of 1906, the Purnell Act of 1925, the Bankhead-Jones Act of 1935 (which provided for matching funds by the States) and other Federal legislation. All this resulted in the formation of at least one agricultural experiment station in each State. As time went on, State and private sources supplemented Federal and State matching funds. In 1955, the several acts were consolidated by the Congress into a revised Hatch Act (6).

U.S. public policy in support of research and education in the technology and organization of farming has been termed the single most effective policy element responsible for technical and economic development in agriculture during this century (4). Public investment in this research has been substantial, but the returns have far outweighed the costs.

A policy of public investment in research to develop new technical knowledge is virtually unique to agriculture, since in most other economic sectors private industries conduct their own research. As a result, society in general and farmers and consumers of farm products in particular have received the benefits which otherwise would have accrued to private industries.

An important aspect of public agricultural research policy is Federal-State cooperation. Research on problems confined within the borders of a State is primarily the responsibility of the experiment station in that State. Research on regional or national problems may be conducted separately by the USDA and individual experiment stations, or by cooperative effort--depending on the specific problems involved and the availability of specialized staff and facilities. In practice, research carried out by USDA and the State experiment stations is often interrelated and intermeshed.

Agencies other than USDA and the land-grant universities also are involved in food and agricultural research. These include the Department of Commerce, and the National Oceanographic and Atmospheric Administration (NOAA), which carries out a program on ocean fisheries. The Food and Drug Administration is mainly concerned with the problems of food contamination. The National Science Foundation finances food research mainly in the biological sciences, some of it through the USDA-State experiment station system.

Important agricultural research is also carried out by the private sector, much of it in cooperation with USDA and the universities. Examples include the development of agricultural chemicals and machines designed for specialized operations. The Tennessee Valley Authority has developed cheaper and more effective fertilizers, as have many private industrial laboratories. Research in both natural and social sciences by the nonland-grant universities also has made important contributions to solving agricultural problems.

U.S. public policy on food and agricultural research also has an international dimension through the Agency for International Development (AID) and other agencies and organizations. This includes support for Consultative Group on International Agricultural Research (CGIAR). In addition, some of the accumulated credits in foreign currency under PL 480 have been used to support agricultural research of mutual interest to the U.S. and the country holding these credits. These cooperative projects have involved 32 nations.

Concern about the world food situation, with all its ramifications, domestically and internationally, has rekindled interest in agricultural research. Uncertainty about food supplies for both the short and long run has led to proposals to increase the allocation of

research resources to agriculture. But that renewal of interest has yet to be translated into strengthened public research policy or greater financial support. In recognition of the critical world food problem, the World Food Conference put increasing agricultural production, in both developed and developing countries, at the top of its agenda. The impact of the recommendations made by the Rome Conference on policy and programs of agricultural research must await the outcome of both domestic deliberations and international consultations set in motion after the Conference.

Policies on the World Food Problem

U.S. international food policies have been carried out largely as part of our foreign aid program. There are two major programs: food assistance under PL 480 and agricultural development assistance carried out by the Agency for International Development.

Food Aid--Large quantities of food have been supplied to foreign countries under the Agricultural Trade Development and Assistance Act of 1954, commonly known as PL 480 or "Food for Peace." PL 480 is administered by the USDA in cooperation with AID, other Federal agencies and private charitable organizations.

PL 480 presently consists of two food aid activities. Under Title I of the Act, the U.S. makes agricultural products available to foreign governments on a long-term dollar credit basis or in exchange for convertible local currency. Currently, most Title I sales are for dollars but throughout the 50's and 60's commodities were largely paid for in local currency under highly concessional terms.

The donations program under Title II provides emergency food relief in the event of natural or other disasters and also support for humanitarian and development activities. Food is channeled through U.S. bilateral programs, voluntary agencies, and international organizations such as the United Nations' World Food Program.

Since 1954, the U.S. has provided \$26 billion in food aid under PL 480. This is in addition to the Marshall Plan following World War II, the Point Four Program, the various AID programs, and assistance from universities and private foundations. The voluntary agencies have had an important role--both on their own and with commodities provided under PL 480. In the period 1965 to 1973, the U.S. provided over four-fifths of the food aid from developed to developing countries (8).

Beginning in fiscal 1973, however, U.S. food aid policy has operated under changed conditions. The surplus situation abruptly came to an end in 1972 when unfavorable weather in a number of major producing and importing regions--the Soviet Union, India, Australia, Sahelian Africa, and Southeast Asia--sharply reduced world agricultural production. Subsequent demands on supplies depleted world grain stocks to extremely low levels. In 1974, the lowest level of PL 480 exports in 20 years was shipped--\$850 million in commodity costs and a volume of 3.3 million tons. In 1975, total commodity exports are expected to be more than \$1.4 billion in value and more than 5.6 million tons. About \$500 million of this will be in the form of government-to-government donations or donations through voluntary agencies.

The tight supply-demand conditions of 1972-74 demonstrated the dependence of the PL 480 program on the existence of surpluses. This development highlighted the conflict that exists between U.S. policy to expand commercial exports of agricultural products and the policy to meet food needs of developing countries.

In addition to having provided large quantities of food to meet the emergency food or balance of payments needs of many countries, the PL 480 program has been a convenient means of disposing of surplus supplies of agricultural products which resulted from a policy of maintaining high price supports. As a consequence it helped to reduce the costs to taxpayers of storing large quantities of grains. It also served to increase the demand for commercial exports as recipient countries became able to purchase additional U.S. farm products at market prices.

With the tight supply situation that existed in 1972-74 and the changes in domestic farm policy toward a more market-oriented agriculture, a clearer realization is emerging of the trade-offs among (a) satisfying the needs of domestic consumers, (b) meeting the requirements of food deficient countries, and (c) meeting the export demands of paying customers. A major issue is the willingness of the U.S. and other developed countries--exporters and importers alike--to commit resources to food needs of developing countries in periods of shortage as well as surplus. International consultations following the World Food Conference will attempt to work out solutions to these and related problems.

Agricultural Development Aid--The second major element in U.S. international food policy is the technical assistance program administered by AID. Technical assistance, including agricultural programs, began in 1949 under the Point IV program. Programs of development grants and loans were later added. In 1961, Congress established AID to consolidate and administer the various activities and agencies that had developed since the end of World War II.

In recent years, U.S. technical assistance programs have emphasized agricultural development. In the Foreign Assistance Act of 1973, Congress called for a revision of U.S. foreign aid policies--a reordering to give priority to helping the "poorest majority" in a developing nation. As a result of this legislation, a larger share of the dwindling foreign aid budget has shifted toward assisting agricultural development, with emphasis on helping small farmers and the rural poor.

U.S. agricultural development assistance has emphasized both the transfer of existing technology to developing countries and the development of new technologies. The limitations on the transfer of technology were not adequately recognized in earlier technical assistance programs. Also, undue emphasis was placed on improving farm extension services in the absence of usable information and technology (2). Realization of these problems led to the creation of CGIAR, a consortium with a membership of 30 governmental and other donor agencies under International Board for Research and Development (IBRD) leadership. CGIAR manages the allocation of resources to the international research institutes such as those which developed high-yielding varieties of wheat and rice.

The annual cost to the U.S. foreign aid is slightly more than 1 percent of the Federal budget. Of this amount, about one-third is devoted to development, including agricultural assistance. Among the 17 members of the Development Assistance Committee of the OECD, the U.S. stands 14th in the amount of foreign aid provided in relation to Gross National Product (GNP). The U.S. figure is less than one-quarter of 1 percent of GNP.

World Food Conference--The World Food Conference of 1974 was convened by the United Nations to develop a worldwide strategy for dealing with the medium- and long-range issues of food production and availability. The Conference adopted a five-point program of proposed worldwide action:

1. Increasing production in food exporting countries
2. Accelerating production in developing countries
3. Improving the means of food distribution and financing
4. Enhancing food quality
5. Ensuring security against food emergencies

The Conference also called on all countries to give a high priority to agricultural and fisheries development, including internal food production and supporting services; external assistance to developing countries; and reduction of waste and crop losses. The Conference recognized the relationship of overall rural development to

adequate food supplies and called for agrarian reforms, when appropriate; for the development of cooperative organizations of farmers and rural workers; and for increased education of rural people. The resolutions of the Conference stressed the need for increased and coordinated international efforts to improve fertilizer and pesticide availability. They also recommended improvement of food consumption patterns, the intensification of crop production, better water management, and more seed production. They called upon all governments to promote a steady expansion and liberalization of world trade.

The Conference recommended the establishment of an International Fund for Agricultural Development. It asked for the development of a global early warning system to furnish all countries with current and timely information on crop and food situations; and for operational and other practical arrangements for an international undertaking on world food security.

The Conference also recognized that the efforts of rural women in the developing world account for at least 50 percent of food production and that women everywhere play a major role in purchase and preparation of food. Therefore, all governments were requested to involve women fully in the decisionmaking machinery for food production and nutrition policies.

The Conference "urged all governments to evaluate the scope and organization of their national agricultural research...programs and their linkages with universities, international and regional institutions, and agro-industry research efforts, with a view to taking all necessary measures...to strengthen national programs to cover priority areas of food and agricultural production more adequately, including inter alia environmental and socio-economic conditions." (9) The recommendation called for research on a regional basis if possible to develop coastal fisheries and marine and inland aquaculture to the fullest.

World Population Policies--Critical to the success of any effort to meet food needs of the world are the government and societal policies--explicit and implicit--which affect population growth. Even though the annual increase in the world population has leveled off to a little under 2 percent during the past 15 years, the present population is nearly double what it was in 1950. Of primary importance to the food problem is the difference in rate of population growth between the developed and the developing countries. Current growth in the developed countries is only 0.9 percent annually, but in the developing countries it is more than 2.5 percent. Furthermore, the developing countries already contain more than 70 percent of the world's population (14).

Proposals for resolving the problems of population growth in all countries are confronted with issues of domestic and international politics, academic theories, ethical principles, and religious and ideological doctrines. These issues are based as much, and possibly more, on perception than fact. The debate ensuing from these issues has led to considerable polarization of political and ideological points of view (12). Nevertheless, the World Population Conference in 1974 adopted a World Population Plan of Action which indicated an "unstated but clearly implicit...outlook for generally declining fertility levels, followed by a drop in the overall population growth rate, leading to an ultimate stabilization resulting from deliberate governmental policy and conscious human choice." (17)

The World Food Conference also adopted a resolution that "calls on all governments and on people everywhere not only to make every possible effort to grow and equitably distribute sufficient food and income so that all human beings may have an adequate diet--a short range goal which priority and the best techniques might make possible--but also to support, for a longer-term solution, rational population policies ensuring to couples the right to determine the number and spacing of births, freely and responsibly in accordance with national needs within the context of an overall development strategy." (9)

These policies, arrived at with difficulty and after debate, recognize that the population problem is not uniform throughout the world and that no one population policy is appropriate for all countries. They are built on the strongly held value that each human has the right to determine his or her own fertility. They consider population programs as a necessary but not sufficient part of economic and social development. They emphasize the need for policies that vigorously promote efforts not only on population control but also on development, including food production.

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RESEARCH CAPABILITIES

Introduction

Research in any field including agriculture is a systematic process of acquiring new facts as a step toward solution of a recognized problem or adding to the store of knowledge which has long range usefulness--often unanticipated.

The public agricultural research system in the United States is mission-oriented. This means, among other things, that it must be responsive to society's needs for an adequate food supply and for effective use and conservation of resources. But agricultural research also faces the demands and dilemmas of the scientific process. This means that innovation can be only partially planned and programmed. Research can be planned; but discovery cannot, since uncertainty of the outcome is inherent in the research process. In any case, there are inherent delays and discontinuities between the stage of basic research and the stage of development and application of research results.

In the United States public agricultural research system, both the scientific community and society's policymakers are involved. Sometimes it is not entirely clear to those conducting research why the policymakers do not see the importance of research in certain areas. Policymakers, on the other hand, often ask why scientists do not see the importance of clear and relevant research reports without undue qualifications.

Much of the research community's efforts are directed at specific goals and targets. However, another role of the scientist is to build a store of basic knowledge and methods that will provide answers to problems of the future. The chief role of the policymakers in either case is to evaluate the research plans and projects in light of society's most pressing needs. All concerned are well advised to keep in mind that:

"...when inventions or other new scientific or technological ideas are conceived, they do not immediately enter the stream of commercial or industrial application...Many never get beyond the stage of conception while others are abandoned during the period of development...Some go through a full course of gestation and finally emerge as new and useful...products, processes, or techniques." (4)

Research to improve the nation's food production and distribution system is a continuous process of becoming aware of problems, finding new facts related to those problems, developing the facts into improved technology, and developing the technology to the stage of economic feasibility which means it can be incorporated into the system--or the system can be changed.

This is the process of mission-oriented research. Agricultural researchers in the United States have the tradition and the present responsibility of carrying out that kind of research. This chapter discusses the organization and the problem-solving capability of public agricultural research in the United States.

The Federal-State System

The prime responsibility for publicly-supported agricultural research in the United States is shared by the U.S. Department of Agriculture (USDA) and the State land-grant universities. Important research contributions also are made by other public institutions and by private firms.

The Nationwide cooperative USDA-State research program has several objectives:

- To solve local, regional, and national problems affecting agriculture, forestry, and other renewable natural resources. This includes work toward an adequate and safe food supply for all consumers; protection of environmental quality; and quality of rural life.
- To provide a continuing flow of new scientific knowledge essential to the solution of future problems.
- To provide scientific competence for teaching, including graduate student research, in order to train future generations of scientists.
- To provide scientific expertise to (a) local, State, and Federal agencies, (b) private organizations and individuals, and (c) programs of overseas agricultural development.

The USDA-State research system includes six Federal research agencies, 56 State agricultural experiment stations, 61 schools of forestry, 16 land-grant colleges of 1890, and Tuskegee Institute. The Federal agencies are largely supported by USDA funds. State experiment stations are funded from several sources. About one-half of their funds come from State governments and about one-fourth from Federal sources. Approximately 60 percent of the total USDA-State research program is funded from Federal sources.

The USDA and the land-grant system of colleges both were established by legislation in 1862. They "grew up together...Confronted by a mutuality of problems, the colleges and the Department matured into a nationwide system of agricultural research and education." (3)

The main purpose of agricultural research by universities, institutions, and Federal agencies other than the USDA-State system is either to contribute to fundamental knowledge, or to further such goals as public health, national defense, utilization of atomic energy, and space exploration. Such research programs, of course, can benefit the scientific problem-solving process aimed at production and use of foods.

In addition, private research by agricultural and food industries, primarily oriented toward development of products and specific management or production techniques, contributes a substantial part of the total national output of agricultural research--probably more than half--in terms of man-years or dollars expended.

Research Coordination and Planning--A crucial component of a large, diverse, multilevel organization such as the USDA-State system is cooperative planning. The Secretary of Agriculture, his Assistant Secretary for Conservation, Research, and Education, and the research planners and directors of the various universities are advised by the Agricultural Research Policy Advisory Committee (ARPAC). This group, which was formed through a memorandum of understanding between the USDA and the National Association of State Universities and Land-Grant Colleges (NASULGC), makes recommendations on broad aspects of research objectives, budget, and program coordination.

The objectives of ARPAC are (a) to recommend policy with respect to planning, evaluating, coordinating, and supporting unified long-range agricultural research programs, and to delineate the appropriate areas of responsibility of Federal and State agencies in carrying out these programs; and (b) to develop further bases for State and Federal cooperation in planning and implementing regional and interstate research programs.

The Assistant Secretary for Conservation, Research, and Education and a dean or president of a land-grant university or college serve as co-chairmen of ARPAC. Total membership is 27.

Joint planning for agricultural research is carried out through a subcommittee of ARPAC, the National Agricultural Research Planning Committee (NPC), and by four regional committees. The membership of NPC and the regional committees consists of university and USDA

science administrators. They develop specific plans for about 50 research programs encompassing the entire range of objectives for agricultural research.

This means that the very broad and long-term objectives of agricultural research are developed with high degrees of interaction among scientists, scientist-administrators at Federal and State levels, and agricultural organizations with policy concerns. Political processes also are involved. The very specific short-run objectives of small segments of the program are largely determined by the scientists and research managers, and, to some extent, clientele groups with specific interests.

The two interlocking components of the publicly-supported USDA-State agricultural research system--each a vast and complex structure in its own right--have their own distinct organizational characteristics. For example, the State experiment stations, being in nearly all cases integral parts of university systems, are academically oriented and organizationally diverse. The USDA is more centrally directed and is closer to the national policymaking process. Brief descriptions of the two public research agencies follow.

State Agricultural Experiment Stations--The typical agricultural experiment station is one of three branches of a college of agriculture in a State land-grant university (see map). The other two branches of the college are concerned with resident instruction and cooperative extension. The experiment station, the primary agricultural research organization of its State, is supported by funds, from several sources--state taxes, Federal funds through the USDA and granting agencies, and grants from private industry.

The three branches of the college of agriculture have their own administrative heads, who report to the dean or vice-president with responsibility for the college. Colleges also are divided into departments, according to fields of science (biochemistry, genetics) or commodities (agronomy, animal science). Both types of departments exist in most colleges--a system that increases opportunities for cooperative research and team problem-solving. Department heads usually are responsible for general program direction of both research and resident instruction. In addition, commodity department chairmen often have an extension role.

The research function of the typical experiment station is closely intermeshed with resident instruction and extension; in fact, the same scientist often is involved in at least two of those activities.

Resident instruction involves undergraduate and graduate students. Over the years, graduate instruction has become an increasingly prominent role of the typical college of agriculture. It consists primarily of (a) formal graduate courses taught by professors who

normally hold titles and responsibilities in the experiment station and (b) research under guidance of committees of professors, also with experiment station responsibilities. Research involving graduate students has become in many universities the primary thrust of experiment station work. As one result, experiment stations have focused increasingly on basic science.

At least partly because of this trend, the role of cooperative extension in direct problem-solving research has increased. These scientific activities usually are shared between an experiment station researcher and the extension specialist in that particular field of interest. Research involving extension personnel concentrates on local or applied aspects of the problem. Extension also serves an important role in identifying researchable problems and their priorities.

In addition to intra-college, coordinated research, teaching and extension functions, the State experiment station programs also often involve USDA scientific input. USDA researchers are located in many university departments and work cooperatively with those departments. These scientists often carry joint titles with the USDA and the university, and may have graduate students or teach seminars or advanced graduate courses.

These research-extension-graduate instruction interrelationships are a fundamental strength of the State agricultural experiment station system. From a functional viewpoint, the lines which separate the various roles are subordinated to the ultimate goals of solving problems and training future scientists and agricultural leaders.

Federal Research Agencies for Agriculture--In addition to its other functions--education, conservation, marketing, regulatory work, agricultural adjustment, surplus disposal and rural development--the USDA is the chief Federal agency for agricultural research. For the Department's overall operations, the Secretary, with the assistance of his staff, proposes programs, program objectives and appropriations to the President through the Office of Management and Budget (OMB).

The Secretary relies heavily on his assistant secretaries and directors in forming research policies and proposals. Direct responsibilities for research are assigned to the Assistant Secretary for Conservation, Research, and Education. Within this branch of the Department, two agencies--Agricultural Research Service (ARS) and the Cooperative State Research Service (CSRS)--share the research charge. The Assistant Secretary also has a coordinative

responsibility for all research including that conducted by the Economic Research Service (ERS).

In coordinating inter- and intra-agency research, the Assistant Secretary works with others within the USDA; confers with organizations representing clientele groups; and maintains staff liaison with other Federal agencies, the National Academy of Sciences, professional societies, and other groups.

Within the USDA, the Environmental Quality Executive Committee helps to coordinate the Department's activities and programs--including research--in the interest of environmental quality.

Agricultural Research Service. ARS conducts and sponsors research in a wide range of technical and scientific fields related to agriculture in its broadest context. In addition to operating research facilities (see map) and programs, it contracts for research with universities and private research organizations.

Research efforts are conducted in close cooperation with the states, other research agencies in USDA, other Federal agencies, industry, foundations, and private groups.

Administratively, ARS is organized into four regions. A regional deputy administrator exercises authority over research conducted in his region, guided by policy and priorities established at the regional level. A National Program Staff concentrates upon insuring the proper interaction, balance, and distribution of research effort--including establishment of long-range research goals and objectives, and development of annual research plans.

ARS operates a network of national and regional research stations with specific problem area responsibilities. State-Federal research coordination involves both these stations and the USDA scientists assigned to State experiment stations.

Cooperative State Research Service. CSRS administers Federal funds for research in agriculture, agricultural marketing and rural life, and for cooperative forestry research. These funds are made available to the State agricultural experiment stations and other designated State institutions in the 50 states and in Puerto Rico, Guam, the Virgin Islands, and the District of Columbia. Most of these funds are allocated to the State experiments stations by formula. Some of them are designated for regional research and for special program grants. A specified percentage must be used for marketing research. CSRS also administers a specific grants program. The cooperative State institutions also receive funds from State legislatures, other Federal agencies, industry, and other sources.

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The technical staff of CSRS reviews research proposals from institutions, conducts on-site reviews of research in progress, gives leadership in planning and coordinating research, and encourages the establishment and maintenance of cooperation among stations and with the Department of Agriculture.

Interinstitutional cooperation is exemplified by regional agricultural research, a concept that dates back before the turn of the century (2).

By team effort, regional research resolves problems too large for a single station or agency. It brings together scientific talent from experiment stations and from Federal agencies and results in both the solution of problems and the application of results more quickly than isolated effort. It also helps to avoid costly duplication of similar research.

The Federal Regional Research Fund (RRF) was activated in 1947 in support of 25 regional projects. The program has expanded to its current level of nearly \$15 million and about 170 projects. Additional State and Federal funds increased the total annual support of the program to nearly \$40 million in fiscal 1973.

Economic Research Service. ERS conducts programs of research in agricultural economics and marketing, both domestic and in foreign commerce, and also coordinates the Department's programs of foreign assistance and training. Projections and forecasts for use within USDA in agricultural policy decisions also are important functions of ERS. The Statistical Reporting Service (SRS) estimates expected production of farm products during each crop year. These forecasts and estimates are essential for policy decisions on production and prices of farm commodities, and are used by ERS in its forecasts.

Patterns of Research Effort and Funding--Scientific effort within the USDA-State research system, including input by forestry schools and certain other cooperating institutions, is reported through the Current Research Information System (CRIS) in the USDA. This system classifies research according to (a) problem areas, of which there are currently 98, arranged in eight groups; (b) activity, which describes the purpose or nature of the research; (c) commodity, resource or technology involved; and (d) scientific discipline. Research efforts also are recorded by scientist-man-years and by dollars spent.

Distribution of research effort by university and USDA scientists among the eight problem areas during 1973 is shown in Table 1. The total of 10,951 scientist-man-years for 1973 is less than 0.5 percent increase over 1966, the year when the CRIS system became operative.

Table 1. Distribution of Agricultural Research Effort of Universities* and USDA - 1973.

Research Program Group	Scientist-Man-Years of Effort		Percent of Total
	<u>Universities</u>	<u>USDA</u>	<u>Total</u>
Natural Resources	733	518	1251
			11.9
Forest Resources	395	964	1359
			12.8
Crops (field and horticultural)	2350	1523	3873
			36.6
Animals	1180	461	1641
			15.5
People, Communities and Institutions	610	351	961
			9.0
Competition, Trade, Adjustment Price and Income Policy	323	463	786
			7.4
General Resource or Technology	529	186	715
			6.8
Unclassified	5	0	5
			0
Total	6125	4466	10591
			100.0

*Includes State Agricultural Experiment Stations, Land-Grant Colleges of 1890, Forestry Schools, and other cooperating institutions.

In 1973, the largest share of effort--36.6 percent--went to crop production, with animal production, forest resources and other natural resources next in line.

Public support for agricultural research is primarily of four types: (a) Federal appropriations for USDA inhouse research; (b) Federal appropriations by way of CSRS for State experiment station research; (c) Federal appropriations through the National Science Foundation (NSF), National Institutes of Health (NIH), the Energy Research and Development Administration (ERDA), and other agencies for competitive grants in the basic sciences; and (d) state appropriations to their agricultural experiment stations.

Trends in funding for agricultural research and development are shown in studies sponsored by NASULGC and the USDA in 1965 (5); and by a CSRS Inventory of Agricultural Research issued in 1974 (7). Federal support for the USDA increased almost 35 percent during that eight-year period. However, a decrease in other Federal funds for agricultural research resulted in an overall increase of 21.9 percent. Meanwhile, funds from states to their experiment stations went up substantially, so that states supported a much higher percentage of their agricultural research in 1973 than in 1965.

Sources of support for research by the USDA-State system in 1973 are listed in Table 2.

Table 2. Sources of Support for Agricultural Research in Universities*and USDA. (millions of \$)

<u>Source</u>	<u>Amount of Support Received</u>		<u>Total</u>
	<u>Universities</u>	<u>USDA</u>	
State appropriations	222.1	--	222.1
USDA	85.8	266.8	352.6
Other Federal	29.6	7.9	37.5
Private industry, sales and other sources	57.5	1.1	58.6
Total	395.0	275.8	670.8

*Includes State Agricultural Experiment Stations, Land-Grant Colleges of 1890, Forestry Schools and other cooperating institutions.

Costs per scientist year of research effort have increased substantially in recent years. For example, the average support per scientist-man-year in State agricultural experiment stations was \$64,497 in 1973, compared to \$37,500 in 1966--an increase of over 70 percent. One reason for the increase is inflation. During that period the Consumer Price Index increased 36.9 percent and figures for implicit price deflation (government purchases of goods and services) rose 54.3 percent. Another reason is that both problems and the research required to solve them have become increasingly complex and costly. Sophisticated instrumentation has made it possible to study intricate biological problems. Enlarged computer capacity has increased output and made feasible the study of relationships which were almost impossible not many years ago. The increased cost of doing research, therefore, reflects to a large extent the inflation of dollars and the increase in output of complex and sophisticated research.

Other Public Agencies, Institutes, The Private Sector

Additional research on agricultural resources and production, on marketing and distribution, and on foods and nutrition is conducted, supported and/or influenced by an array of agencies and groups. These include public agencies, industries, private foundations, international institutes, and various societies and organizations.

Other Public Agencies--Federal agencies with potential input into domestic or international research programs on food and agriculture include the National Science Foundation (NSF); Agency for International Development (AID); Environmental Protection Agency (EPA); Department of Health, Education, and Welfare; Department of the Interior; Department of Defense; Department of Commerce; Department of Labor; National Aeronautics and Space Administration (NASA); Energy Research and Development Administration (ERDA); and the Tennessee Valley Authority. In addition, various State agencies with interests in food, agriculture, or the environment may make or influence decisions on agricultural research.

Private Industry--Private industry spends large amounts on agricultural research and development, primarily to promote technological development (5,6). Part of these funds are in support of public research.

The extent or volume of the research effort by the private sector, the kinds of research and development undertaken, and the relation of private research to Federal and State programs have not been reported in detail since 1966.

At that time, industry was the largest single source of support for agricultural research and development in the United States, providing 54 percent of the total funds available in fiscal 1965 (5). In that year, an estimated \$473 million went for research on such developments as improved seed, plants and animal breeding stock; biologics, pesticides, fertilizers, feeds, product development and consumer testing; and equipment and facilities for production, processing and marketing. If it is assumed that the increases from 1965 onward were equal each year, industry would have invested over \$700 million in agricultural research and development by 1973. However, actual figures are not available.

Private Foundations--In the United States and overseas, private foundations support programs in two main areas: (a) research in agriculture to increase production and utilization of food supplies; and (b) development of human resources. Of \$473 million available from private sources for United States agricultural research and development in 1965, \$22 million came from private foundations.

The Rockefeller Foundation has participated in overseas food and nutrition programs in its effort "to promote well-being of mankind through advancement of knowledge and its effective application to human needs and interests." (1) The support for agriculture is directed toward activities which the Foundation believes will contribute most effectively to the rapid increase of food production--particularly programs in nations which have indicated a strong desire to raise their agricultural production and their willingness to provide support in the form of local currency, personnel, facilities, and governmental policy.

The Ford Foundation has supported a sizable program to assist in agriculture, rural village development, and home economics. Primary emphasis of the Ford Foundation has been on education and training of young scientists. The Ford and Rockefeller Foundations have joined in initiating programs such as those at the International Rice Institute in the Philippines.

The Kellogg Foundation has placed emphasis on supporting nonpartisan educational, agricultural, and health activities in the public interest. It contributed \$21 million for the fiscal year ending August 31, 1973, "to narrow the gap between creation of knowledge and its use for the public good." (1)

International Institutes--The Consultative Group on International Agricultural Research (CGIAR) was founded in 1971 after several years of informal communication among donors to international agricultural research. CGIAR serves as an overall consultative body. Its goals are (a) to seek long-term financial support for the

international agricultural research centers; (b) to consider proposals for new centers; (c) to suggest high priority agricultural research activities and seek financing for them; (d) to consider specific proposals on research needs and suggest studies on their feasibility and implementation; and (e) to review and consider how to meet special needs of developing countries for agricultural research and associated training..

CGIAR had 30 members as of August 1974, about 20 of whom were donors. Membership included representation from each of the five developing regions--Latin America, Africa, Asia and the Far East, Middle East, and Southern and Western Europe. Three sponsoring groups are the World Bank (IBRD), Food and Agriculture Organization (FAO), and the United Nations Development Program (UNDP).

CGIAR is presently serving a number of existing international centers, more that are in the process of being established, and additional related activities. In 1974 the donor members contributed approximately \$33 million to meet the financial needs of these ten enterprises. Requirements for 1975 are estimated at \$47 million. AID is the largest donor, providing about 25 percent of the core and capital budget requirements of the centers and other CGIAR activities.

The research centers and programs are:

1. IRRI - The International Rice Research Institute is located in the Philippines. The primary objective has been to increase the production of rice in the world, especially in Asia, and to improve its quality. Work on rice per se is being substantially strengthened by development of a complementary multiple cropping systems research program.
2. CIMMYT - This is the Spanish acronym for the International Center for Maize and Wheat Improvement which is located in Mexico. CIMMYT is concerned primarily with maize and wheat, but also has limited research programs on barley, triticale and cold-tolerant sorghum.
3. IITA - The International Institute of Tropical Agriculture is located in Nigeria. It focuses on four basic research programs; cereal improvement (rice and maize) with important links to IRRI and CIMMYT; grain legumes (principally cowpeas and soybeans); roots and tubers (principally cassava, sweet potatoes, and yams); and farming systems for the lowland, humid tropics.

4. CIAT - The Spanish acronym for the International Center for Tropical Agriculture which is located in Colombia. CIAT's primary areas of research are on beef cattle, cassava, beans and farming systems. It also has modest maize and rice programs which are strongly linked with CIMMYT and IRRI, for backstopping. Finally, CIAT has a swine program of limited scope which is concerned primarily with management and nutrition problems.
5. CIP - The Spanish acronym for the International Potato Center which is located in Peru. CIP is a single-crop institute devoted to the tuber-bearing species Solanum--the white or Irish potato.
6. ICRISAT - The International Crops Research Institute for the Semi-Arid Tropics is located in India. ICRISAT's mandate is to develop as a world center of excellence for improvement in the genetic potential and production techniques of sorghum, millets, pigeonpeas, and chickpeas; and to promote the development of improved cropping patterns and farming systems in the semi-arid tropics. It is expected to begin a modest program of peanut improvement.
7. ILRAD - The International Laboratory for Research on Animal Diseases is being established in Kenya. ILRAD will develop a sustained fundamental research program focusing on immunological and related aspects of trypanosomiasis and theileriosis (primarily East Coast fever), two of the most devastating diseases of cattle in the tropics--particularly in Africa.
8. ILCA - The International Livestock Center for Africa is to be based in Ethiopia. It will be concerned with identification of improved major animal production systems in tropical Africa, and in assisting the governments and authorities responsible for achieving new levels of productivity.
9. IBPGR - The International Board for Plant Genetic Resources has its headquarters and Secretariat at FAO in Rome. The basic function of the Board is to promote an international network of genetic resources activities to further the collection, conservation, documentation, evaluation, and utilization of plant germplasm.
10. WARDA - The West Africa Rice Development Association has its headquarters in Liberia. The CGIAR supports part of WARDA's research (the W-1 program) which involves coordinated rice trials in 12 West African countries.

11. ICARDA - International Center for Agricultural Research for Dry Areas is located in Lebanon, Syria, and Iran.

Associate status or in process of active consideration or organization:

12. AURDA - The Asian Vegetable Research and Development Center is in Taiwan.
13. IFRDC - International Fertilizer Research and Development Center is located in the United States at Muscle Shoals, Alabama.

Related activities:^{a/}

14. ISRC - The International Soybean Research Center functions as part of the system, but is funded and managed without a direct link to the system.
15. IFPRI - The International Food Policy Research Institute in Washington, D. C., is related to the system, but not funded directly by the system.

Groups, Societies, and Organizations

Through the auspices of many scientific, farm, industry, and other private organizations, agricultural researchers from the Federal government, universities, and industry are brought together. Through conferences and meetings, there is much interaction among scientists and industry, and among scientists in a variety of fields. These groupings include:

Professional Societies--Agricultural scientists participate in many national and international scientific and professional societies. These groups and their journals provide opportunities for agricultural scientists to publish research results, to exchange ideas and to otherwise benefit from association with others working in their specialized fields.

The National Association of State Universities and Land-Grant Colleges (NASULGC)--In 1887, the Association of American Agricultural Colleges and Experiment Stations was formed. In 1963, this association joined with two others--the National Association of

^{a/} Ruttan, Dr. Vernon W. Paper presented to the Working Conference on Research to Meet U.S. and World Food Needs, July 9-11, 1975, Kansas City, Missouri.

State Universities, formed in 1895, and the American Council on Education, formed in 1918--to create NASULGC. The Association's Division of Agriculture includes a Council of Administrative Heads and three sections dealing with experiment stations, the cooperative extension service and resident instruction in agriculture. The legislative committee of the Division is responsible for making budget recommendations to the USDA on appropriations for experiment stations, cooperative extension service and forestry research.

Through the Experiment Station Section, the State experiment station directors exchange information and ideas and develop objectives, plans, and policies.

National Academy of Sciences (NAS)--NAS was set up by Congress in 1863. It was empowered to create its own organization and bylaws; in addition, its charter called upon the Academy to serve as an official advisor, upon request and without fee, to the Federal government on any question of science or technology. Although NAS is not a government agency, it has maintained a close relationship. The National Research Council (NRC) was organized by the Academy in 1916, in the interest of national preparedness. The work of the NRC is performed through permanent boards, institutes, committees, sub-committees, and panels, as well as by ad hoc groups for special projects. The operating budget of the Academy, largely devoted to carrying out the activities of the NRC, is derived from contributions, grants, and contract funds received from Federal and State agencies, private industries and foundations, scientific societies, and individuals.

Many agricultural scientists participate in the NAS and its subsidiary organizations. Through the Academy, agricultural scientists work with scientists from other fields on scientific matters of public concern. Within the Academy, the Board of Agriculture and Renewable Resources (BARR) has fostered the orderly development of sciences related to agriculture in their broadest aspects.

Agricultural Research Institute (ARI)--Agricultural science administrators and scientists from industry, universities, and government form the non-government ARI; its goal is to identify and promote the kinds of research and policies needed to ensure the best long-term utilization of agricultural resources for the national welfare. The activities of the ARI are carried out through about 15 standing and special committees. Studies made by the special committees range from pesticides to agriculture in relation to the quality of the environment.

National Industry-State Agricultural Research Council--This informal organization of agricultural organizations and industries serves as

a forum for (a) discussion of agricultural research needs from the viewpoint of the nation's agricultural associations, organizations, and industries; (b) review of research in progress or being planned by the State agricultural research agencies; (c) review of legislative and fiscal matters affecting the nation's agricultural industry and the State agricultural research agencies; and (d) planning to achieve adequate levels of support for programs of research deemed most urgent.

Council for Agricultural Science and Technology (CAST)--This is an educational organization composed of a group of agricultural science societies. Its purpose is to increase the effectiveness of agricultural scientists as sources of information for the government and the public on the science and technology of agricultural issues of broad national concern. CAST's projects are carried out by task forces of scientists serving as individuals, not as representatives of their employers. Only short-term projects are undertaken.

Conclusion

The United States scientific establishment devoted to public research on agricultural resources and on food production and delivery systems has three particular strengths: large size, diversity, and experience in practical problem-solving.

Involving half a dozen Federal agencies and more than half a hundred State research organizations, the USDA-State system is literally in contact with all parts of the nation and with all aspects of the nation's agricultural resources. A chief advantage is the diversity of its organizational structure and of its funding sources. A complex Federal-State network, it is responsive to many segments of society as well as to the scientific community.

Assuming that levels of support will at least parallel those of the past, it seems certain that the United States agricultural research system can respond effectively to the new challenges of increased food demand at home and abroad. The organizational base is sound; the expertise is there. One remaining question concerns the flexibility of the agricultural research establishment--its ability to respond to new conditions and new demands, as all social and political structures must in an age of rapid change.

The publicly-supported agricultural research programs are linked to, and supplemented by, the private industrial research organizations. Most emphasis by industrial researchers is on shorter-range developmental projects. This can be beneficial for its own sake, and also to the extent that it permits experiment station and Federal scientists to pursue the longer-range problems--to achieve the all-

important "lead time" in problem solving that is a chief hope of this nation and of the world as mankind's need for food increases.

The Conference delegates and participants considered the strengths of the United States scientific community as they developed the list of priority research needs upon which efforts should be expended in the years ahead. The extent of these efforts will be an important factor in how effective the United States is in increasing and improving domestic and world food supplies.

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APPENDICES

APPENDIX A

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TO THE

WORKING CONFERENCE ON RESEARCH TO MEET U.S. AND WORLD FOOD NEEDS

Kansas City, Missouri
July 9-11, 1975

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WORKING CONFERENCE ON RESEARCH TO MEET U.S. AND WORLD FOOD NEEDS

Kansas City, Missouri
July 9-11, 1975

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